

## CLAIMS

1. A system for tracking the position of an instrument relative to an area of interest, comprising:

a first fixator secured to a first point along said area of interest, said first fixator being configured to carry first and second localizing devices;

a second fixator secured to a second point along said area of interest, said second fixator being configured to carry said first localizing device; and

a third localizing device positioned proximate a third point along said area of interest, said second point being located proximate said first and third points, said third localizing device communicating with said first localizing device at said second fixator and said second localizing device at said first fixator communicating with said first localizing device at said second fixator such that the position of said second localizing device at said first fixator can be determined relative to the position of said third localizing device proximate said third point, said second localizing device at said first fixator being attachable to said instrument and said first localizing device at said second fixator being attachable to said first fixator such that said first localizing device on said first fixator communicates with said second localizing device on said instrument in order that the position of said second localizing device on said instrument can be determined relative to said first localizing device on said first fixator and to said third localizing device proximate said third point.

2. The system of claim 1, wherein said first localizing device is an electromagnetic transmitter and said second and third localizing devices are electromagnetic receivers.

3. The system of claim 1, wherein said first, second, and third localizing device are emitters for use in an optical tracking system.

4. The system of claim 1, further comprising a computer system that monitors the communications between said first, second, and third localizing devices and calculates their relative positions.

5. The system of claim 1, wherein additional localizing devices may be positioned about said area of interest.

6. The system of claim 1, further comprising a C-arm having an imaging device and said third localizing device and being positioned proximate said third point, said imaging device taking an image of said area of interest, said third localizing device communicating with said first localizing device such that the positions of said first and second localizing devices can be determined relative to said image.

7. The system of claim 1, wherein said first fixator is rigidly secured to a patient's body by bone screws and is configured to carry an electromagnetic transmitter and an electromagnetic receiver.

8. The system of claim 1, wherein said second fixator is secured to a patient's body by connectable strap and is configured to carry an electromagnetic transmitter.

9. A system for localizing instruments relative to a patient's bone comprising:

an electromagnetic localizing device with an electromagnetic field transmitter and an electromagnetic field receiver;

a fixator for attaching to bone, said fixator being capable of attaching a transmitter and receiver in a fixed and known position relative to one another;

a first surgical instrument with an attached transmitter;

a second surgical instrument with an attached receiver;

means for determining the position of the first surgical instrument relative to the fixator with an attached transmitter;

means for determining the position of the second surgical instrument relative to the fixator with an attached receiver; and

means for calculating the position of the first surgical instrument relative to the second surgical instrument.

10. A system for electromagnetically tracking the position of a surgical instrument relative to an image of a patient's body, comprising:

a C-arm positioned proximate a first point of said body, said C-arm including an imaging device and an electromagnetic receiver, said imaging device taking an image of said body;

a first fixator joined to said body at a second point proximate an area of interest, said first fixator being configured to carry an electromagnetic receiver and an electromagnetic transmitter; and

a second fixator positioned at a third point of said body proximate said first and second points, said second fixator configured to carry an electromagnetic transmitter, said transmitter at said second fixator communicating with said receivers at said C-arm and said first fixator such that the position of said receiver at said first fixator can be determined relative to the position of said receiver on said C-arm and said image, said receiver at said first fixator being attachable to said surgical instrument and said transmitter at said second fixator being attachable to said first fixator such that said transmitter communicates with said receiver on said surgical instrument in order that the position of said receiver on said instrument can be determined relative to said transmitter on said first fixator and to said receiver at said C-arm and said image.

11. The system of claim 10, further comprising a computer system that monitors the communications between said transmitter and said receivers and calculates their relative positions to each other.

12. The system of claim 10, wherein the position of said transmitter on said first fixator can be determined relative to the position of said receiver on said first fixator in order that the position of said transmitter on said first fixator relative to said receiver at said C-arm may be determined.

13. The system of claim 10, wherein additional transmitters and receivers may be positioned about said patient to communicate with each other.

14. The system of claim 10, wherein said C-arm calibrates the position of the receiver at said C-arm relative to the image such that when said transmitter communicates with said receiver at said C-arm, the position of said transmitter relative said image may be calculated.

15. The system of claim 10, wherein said first fixator is rigidly secured to the patient's body by bone screws.

16. The system of claim 10, wherein said second fixator comprises a post and lock spring for securing said transmitter thereto and connectable straps for externally securing said second fixator to the patient's body.

17. The system of claim 10, wherein said first fixator comprises a post and lock spring for securing said transmitter thereto and a connection block for securing said receiver thereto.

18. A method for extending the operating range of a tracking system using localizing devices, comprising:

connecting a first fixator carrying a first localizing device to a first point proximate an area of interest;

connecting a second fixator carrying a second localizing device to a second point proximate the area of interest;

positioning a third localizing device at a third point, said second point being located proximate said first and third points;

providing said first and third localizing devices in communication with said second localizing device such that the position of said first localizing device relative to said third localizing device may be calculated;

removing said first localizing device from said first fixator and attaching said first localizing device to an instrument proximate said area of interest;

removing said second localizing device from said second fixator and attaching said second localizing device to said first fixator; and

providing said first and second localizing devices in communication with each other such that the position of said first localizing device on said instrument relative to said third localizing device may be calculated.

19. The method of claim 18, wherein said first and third localizing devices are electromagnetic receivers and said second localizing device is an electromagnetic transmitter.

20. A method for extending the spatial operating range of an electromagnetic localizing system comprising the steps of:

providing a first surgical instrument with an attached receiver;

providing a second surgical instrument with an attached transmitter;

providing a fixator to which a receiver and a transmitter attach;

calculating the position of a receiver attached to the fixator relative to a transmitter attached to the fixator;

attaching a receiver to the fixator;

determining the position of the first surgical instrument relative to the receiver attached to the fixator;

removing the receiver from the fixator;

attaching a transmitter to the fixator;

determining the position of the second surgical instrument relative to the transmitter attached to the fixator; and

calculating the position of the first surgical instrument relative to the second.

21. A system for extending the operating range of a tracking system using localizing devices, comprising:

a first fixator connected to a first point proximate an area of interest, said first fixator being configured to carry a first localizing device;

a second fixator at a second point and proximate said first point, said second fixator being configured to carry a second localizing device;

a first instrument configured to carry a third localizing device, and said third localizing device on said first instrument communicating with said second localizing device at said second fixator in order that the position of said third localizing device can be determined relative to said second localizing device, said second localizing device communicating with said first localizing device at said first fixator in order that the position of said third localizing device on said first instrument can be determined relative to the position of said first localizing device at said first fixator; and

a second instrument configured to carry a fourth localizing device, said fourth localizing device communicating with said first localizing device at said first fixator in order that the position of said fourth localizing device on said second instrument can be determined relative to said first localizing device on said first fixator and to the position of said third localizing device on said first instrument.

22. A system for extending the operating range of a tracking system using localizing devices, comprising:

a first fixator connected to a first point proximate an area of interest, said first fixator being configured to carry first and second localizing devices, such that the positions of said first and second localizing devices on said first fixator are fixed and known relative to one another;

a second fixator at a second point proximate said first point, said second fixator being configured to carry said second localizing device;

a first instrument configured to carry a third localizing device, said third localizing device communicating with said second localizing device on said second fixator in order that the position of said third localizing device can be determined relative to said second localizing device, said second localizing device communicating with said first localizing device on said first fixator such that the

position of said third localizing device on said first instrument can be determined relative to the position of said first localizing device on said first fixator; and

a second instrument configured to carry a fourth localizing device, said fourth localizing device communicating with said second localizing device at said first fixator in order that the position of said fourth localizing device on said second instrument can be determined relative to said second localizing device on said first fixator; and such that the position of said fourth localizing device on said second instrument can be determined relative to said position of the third localizing device on said first instrument.

23. The system of claim 22, wherein said second localizing device is an electromagnetic transmitter and said first, third and fourth localizing devices are electromagnetic receivers.

24. The system of claim 22, wherein said first instrument carrying said third localizing device is a C-arm having an imaging device and being positioned proximate said first point, said imaging device taking an image proximate said first point such that the position of said second localizing device at said first fixator can be determined relative to said image.

25. The system of claim 22, wherein said second instrument is a C-arm having an imaging device and being positioned proximate said second point, said imaging device taking an image proximate said second point, said fourth localizing device communicating with said second localizing device such that the position of said second localizing device at said first fixator can be determined relative to said image.

26. The system of claim 22, wherein said first, second, third, and fourth localizing device are emitters for use in an optical tracking system.

27. The system of claim 22, further comprising a computer system that monitors the communications between said first, second, third, and fourth localizing devices and calculates their relative positions.

28. The system of claim 22, wherein additional localizing devices may be positioned about said area of interest.

29. The system of claim 22, wherein said first fixator is rigidly secured to a patient's body by bone screws and is configured to carry an electromagnetic transmitter and an electromagnetic receiver.

30. The system of claim 22, wherein said second fixator is secured to a patient's body by connectable strap and is configured to carry an electromagnetic transmitter.

31. The system of claim 22, wherein said known relationship between said first and second localizing devices at said first fixator is determined by manufacture of said first fixator.

32. The system of claim 22, wherein said known relationship between said first and second localizing devices at said first fixator is determined by a calibration procedure.

33. A fixator for use with a surgical tracking system, comprising:  
a means for attaching a first localizing device; and  
a means for attaching a second localizing device such that the first localizing device is held in a fixed and known relationship to the second localizing device.

34. The fixator of claim 33, wherein said known relationship between said first and second localizing devices at said fixator is determined by manufacture.

35. The fixator of claim 33, wherein said known relationship between said first and second localizing devices at said fixator is determined by a calibration procedure.

36. The system of claim 35, wherein said calibration procedure comprises the calculation of the positions of said first and second localizing devices by a surgical tracking system.



37. A system for localizing instruments relative to a patient's bone, comprising:

- a fixator for attaching to bone, said fixator being configured to carry a transmitter and receiver in a fixed and known position relative to one another;

- a first surgical instrument with an attached receiver;

- a second surgical instrument with an attached receiver;

- means for determining the position of the first surgical instrument relative to said fixator with an attached transmitter;

- means for determining the position of the second surgical instrument relative to the fixator with an attached receiver; and

- means for calculating the position of the first surgical instrument relative to the second surgical instrument.

38. The system of claim 37 wherein said means for determining the position of the second surgical instrument relative to said fixator comprises a second fixator with a transmitter, said transmitter in communication with said receiver attached to said second surgical instrument and with a receiver attached to said first fixator.

39. A method for extending the spatial operating range of an electromagnetic localizing system comprising the steps of:

- providing an electromagnetic localizing device with an electromagnetic transmitter and receiver;

- providing a first surgical instrument with an attached receiver;

- providing a second surgical instrument with an attached receiver;

- providing a fixator to which a receiver and a transmitter attach;

- determining the position of a receiver attached to the fixator relative to a transmitter attached to the fixator;

- attaching a receiver to the fixator;

- determining the position of said first surgical instrument relative to said receiver attached to said fixator;

- removing said receiver from said fixator;

- attaching a transmitter to said fixator;

determining the position of said second surgical instrument relative to said transmitter attached to said fixator; and

determining the position of said first surgical instrument relative to said second surgical instrument.

40. The method of claim 39 wherein the step of determining the position of said first surgical instrument relative to said receiver attached to said fixator comprises the steps of:

providing a second fixator with a transmitter;

determining the position of said receiver on said first surgical instrument relative to said transmitter on said second fixator;

determining the position of said receiver on said fixator relative to said transmitter on said second fixator; and

determining the position of said receiver on said first surgical instrument relative to said receiver on said fixator.

41. A method of determining the position of an image of a first area of interest relative to a second area of interest comprising the steps of:

connecting a first fixator carrying a first localizing device to a first point proximate said first area of interest;

connecting a second fixator carrying a second localizing device to a second point proximate said second area of interest;

providing an imaging device configured to acquire an image of an area of interest and carrying a third localizing device;

determining a first position of said third localizing device relative to said second localizing device;

determining a first position of said first localizing device relative to said second localizing device;

acquiring an image of said first area of interest with said imaging device;

determining a second position of said third localizing device relative to said second localizing device;

determining a second position of said first localizing device relative to said second localizing device;

calculating the difference between said first and second positions of said first localizing device relative to said second localizing device and the difference between said first and second positions of said third localizing device relative to said second localizing device;

calculating the position of said third localizing device relative to said first localizing device if said difference is less than a predetermined threshold; and

indicating an error if said difference is greater than said predetermined threshold.